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Econometric Estimation of the Magnitude of Market Power in the Soymeal Export Market*.

Satish Y. Deodhar (The Ohio State University, USA)

Ian M. Sheldon (The Ohio State University, USA)

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Abstract:

In this paper, an estimate of the degree of imperfect competition in the market for soymeal exports is derived using a structural econometric model. The procedure consists of estimating a demand function and the industry first-order profit-maximization condition, from which an estimate of the degree of imperfect competition can be retrieved. Using a nonlinear three-stage least squares procedure, the estimate of market power shows that the world market for soymeal exports is perfectly competitive.

Keywords: Imperfect competition, soymeal exports

1. Introduction

Over the past fifteen years industrial economics has seen a resurgence of interest in the conduct of empirical analysis, an activity which is now commonly referred to as the "new empirical industrial organization" (NEIO). This new empirical research has developed largely due to dissatisfaction with the older structure-conduct-performance (SCP) methodology that dominated empirical work in industrial organization during the 1960s and 1970s (Bresnahan and Schmalensee, 1987; Bresnahan, 1989). Typically studies in the NEIO use time-series data from a single industry to estimate structural econometric models based on firm-level optimization behavior in order to determine market outcomes. Essentially, the approach is aimed at evaluating the presence of market power in a specific industry based on the specification of demand and cost functions and hypotheses concerning the strategic interaction of firms, things which studies based on the SCP approach generally failed to specify.

Of the various applications of this new methodology to the food and agricultural sector, only a few relate to export markets, for example, Buschena and Perloff (1991), coconut oil export market; Karp and Perloff (1989, 1993), rice and coffee export markets; Lopez and You (1993), Haitian coffee exporting; and Deodhar and Sheldon (1995), German banana imports. In the context of the NEIO, estimating the degree of imperfect competition in international markets is a logical extension of the methodology, however, it takes on further importance in the light of recent developments in international trade theory (Helpman and Krugman, 1985, 1989).

The defining feature of the "new trade theories" is the explicit assumption that trade can be characterized by markets that are imperfectly competitive, an assumption that has generated three basic predictions: first, scale economies can lead to specialization and export in monopolistically competitive markets, e.g. Helpman and Krugman (1985); second, oligopolistic markets can provide a rationale for activist trade policies such as export subsidies and taxes, e.g. Brander and Spencer (1985); third, imperfect competition can affect the gains from trade liberalization, e.g. Smith and Venables (1988), and, different trade instruments can have differential welfare effects when markets are oligopolistic, e.g. Krishna (1989). These developments suggest there are additional reasons why it matters to verify empirically that an international market(s) is(are) imperfectly competitive. In this context, therefore, the objective of this paper is to estimate the degree of imperfect competition in the market for soymeal exports, using a structural econometric model based on a model originally suggested by Bresnahan (1982). This is an interesting agricultural export market to analyze due to the fact that, in contrast to previous studies, soybean processing is an industry where firms from both developing and developed countries are competing with each other.

It should be noted that an earlier study by Yamazaki, Paarlberg and Thursby (1992) did evaluate competition in the soybean processing industry using a model that allowed retrieval of a value for an aggregate conjectural variations[1] parameter for the industry which suggested that the export market is perfectly competitive. However, Yamazaki *et al.* used a simple non-stochastic computable partial equilibrium model which does not allow for the calculation of standard errors for the estimated degree of market power[2], unlike the present study. In addition, the previous study did not separate the markets for processed soybean products, soymeal and soyoil. Although these are obtained simultaneously in the processing operation,

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[1] Conjectural variations are an index of the beliefs that firms' have about the response of other firms to their actions.

[2] See Sheldon (1992) for a discussion of the use of this type of model.

soymeal and soyoil are sold in virtually independent markets, having a single identifiable world market for each of them (Uri, Chomo and Hoskin, 1993). Hence, the present study focuses on the degree of competition in the soymeal export market[3].

Given the basic objective, the remainder of the paper is organized as follows: Section 2 gives background information on the structure of the world soymeal export market, while section 3 describes the econometric methodology followed in the paper. Essentially, the degree of imperfect competition in the international market is calculated by estimating a demand function and the industry first-order profit-maximization condition, from which an estimate of the degree of imperfect competition can be retrieved. Section 4 describes the data used, and reports the results of the econometric analysis, while Section 5 summarizes.

2. Soymeal Export Market Structure

The soymeal export market is a major agricultural export market, world demand for soymeal deriving mostly from the demand to feed livestock and manufacture food products, a demand that has been growing constantly due to ever increasing world per-capita incomes and population. The world market for soymeal exports has increased rapidly from less than three million tonnes in 1966 to approximately 29 million tonnes in 1994, an increase of more than 800 percent (American Soya Association). Soymeal production is an extremely valuable part of soybean processing, 80 percent of the value of soybeans being derived from the soymeal market (Larson and Rask, 1992). In addition, soymeal holds a dominant position in the protein meal

[3] An initial attempt was made to conduct a similar study on soyoil, however, it was dropped due to data problems. Specifically, there is not enough variability in the quantities of soyoil exports to allow estimation of a demand function, and data on the prices of an important substitute product, rapeseed oil, were not available for the entire period used in the study.

market, accounting for more than 60 percent of the world market in 1994, there being no major competing substitutes (American Soya Association).

In terms of the geographic structure of soymeal exports, Larson and Rask report that more than 95 percent of world exports are accounted for by four countries/country blocs, namely Argentina, the European Union (EU-12), the U.S. (20 percent each), and Brazil (35 percent). Argentina is a relative newcomer which began exporting during the mid-1970s, growing from a 2 to a 20 percent share of the world market over the period 1980 to 1990, largely at the expense of the U.S. and Brazil. Larson and Rask suggest that Argentina and Brazil have a relative competitive advantage in the sector partly due to lower soybean production costs, but also due to the use of differential trade instruments designed to promote the export of processed soybeans.

On the face of it, the extent of country participation in the global trade of soymeal suggests that the export market might be characterized by oligopolistic behavior[4], however, closer analysis of the market structure of soybean processing gives no clear empirical indication as to whether or not this market is imperfectly competitive. In the case of the U.S., soybean processing is relatively concentrated. Marion and Kim (1991) report that between 1977 and 1988, the largest four firm's share of soybean crushing capacity rose from 46 to 76 percent, with the largest two firms, Archer Daniels Midland (ADM) and Cargill taking just over 50 percent. This increase in market concentration has come about largely through mergers and acquisitions, although crushing capacity also declined over the same period as firms have concentrated

[4] There has been a tradition in the agricultural trade literature to focus on the competition between countries that dominate the export of certain agricultural commodities, the classic example being the series of papers published on trade in wheat: McCalla (1966); Alaouze, Watson and Sturgess (1978); Karp and McCalla (1983); Kolstad and Burris (1984).

capacity in larger scale plants. Similarly in the EU, soybean crushing is highly concentrated. Scoppola (1995) reports that, in 1988, the four-firm concentration ratio for the EU was 85 percent, all of which was accounted for by multinational corporations. For example, Cargill operates plants in France, the Netherlands, Spain and the UK, while ADM has a plant in the Netherlands. In contrast, while there is also multinational involvement in Brazil and Argentina, their soybean processing industries are considerably less concentrated, with the largest four firms accounting for 27 and 39 percent of crushing capacity respectively in 1994 (American Soya Association). In addition, processing capacity has expanded in both countries since the 1970s (Larson, 1992).

Hence, while the geographic location of the soybean processing is heavily concentrated, and there is evidence of multinational involvement, the structure of the industry cannot be unambiguously described as oligopolistic in structure. In addition, while studies have shown that this industry is characterized by scale economies due to large fixed costs in processing (U.S. International Trade Commission, 1987), there also seems to be chronic excess capacity in the industry which would tend to undermine firms' ability to extract monopoly rents. For example, a 1988 USDA study shows that capacity use in Brazil during the mid-1980s was only 55 percent.

3. Methodology for Estimating Market Power

Most industrial organization economists agree that the appropriate measure of the extent of market power is the gap between price (P) and marginal cost (MC), i.e., the ability of a firm/industry to raise price above marginal cost. A unitless measure of this is the well-known Lerner index:

(1) $$L = \left[\frac{P - MC}{P}\right]$$

In principle, this index could be measured directly, however, detailed information about marginal costs is rarely, if ever, available. Most research in the SCP tradition has, therefore, adopted a proxy for the Lerner index originally introduced by Collins and Preston (1969) that uses average variable cost rather than marginal cost. However, except for competitive firms in long-run equilibrium, average (variable) cost is not a good approximation to marginal cost. An alternative index, Tobin's q, defined as the ratio of the market value of a firm to the replacement cost of its tangible assets, should, on average, equal one under competitive conditions. If, however, intangible assets are large and are ignored in the valuation of the firm, then Tobin's q can exceed one even in the absence of market power. Measures of profits and rates of return are also poor substitutes for the price-cost margin as they are based on accounting definitions of cost, employ arbitrary depreciation rules, and do not treat the cost of advertising and research and development reasonably. Fisher and McGowan (1983) indicate that the time profile of the benefits derived from investments, depreciation methods used, and the growth rates of the firms differ among firms, hence, the comparison of accounting rates of return is misleading.

The NEIO has evolved partly due to dissatisfaction over these measurement issues (Bresnahan, 1989; Perloff, 1992). This literature has grown in several different directions, the variety reflecting the differences in the availability of data and the institutional details of the industries. The approach followed in this paper is based on a model suggested by Bresnahan (1982), and also utilized by Buschena and Perloff. The aim is to estimate an industry-wide, average parameter of market power, using a standard structural econometric method.

Suppose market demand in a given industry is given by the implicit function:

$$Q_t = Q(P_t, Z_t) \tag{2}$$

where Q_t is the total quantity demanded, P_t is market price, Z_t is a vector of exogenous variables, and t is a time subscript. Since Q_t and P_t are simultaneously determined, the demand function can also be written in inverse form, $P_t = P(Q_t, Z_t)$. Industry revenue is defined as, $R_t = P_tQ_t$, hence, perceived marginal revenue $\{MR_t(\lambda)\}$ is given by the expression:

$$MR_t(\lambda) \equiv P_t + \lambda Q_t[dP_t/dQ_t] \tag{3}$$

where λ is the market power parameter reflecting the wedge, in equilibrium, between price and marginal cost. Nested in λ will be an index of the beliefs that firms have about other firms' reactions to their output choices, i.e. a conjectural variations parameter. In equilibrium, MR_t will equal marginal cost MC_t, which can be written as:

$$P_t + \lambda Q_t[dP_t/dQ_t] = MC_t \tag{4}$$

If firms demonstrate either Bertrand-Nash or perfectly competitive behavior, the parameter λ will turn out to be 0, and (4) becomes the usual profit maximizing condition that price must equal marginal cost. If firms demonstrate perfectly collusive behavior, the value of λ will be 1, and λ will take the value 1/n if the n firms in the market behave in Cournot-Nash fashion[5].

The empirical procedure adopted to estimate the degree of imperfect competition in the soymeal export market is as follows. The world export demand function in (2) is specified as a linear equation of the form:

$$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Z_{1t} + \alpha_3 Z_{2t} + \alpha_4 Z_{3t} + \alpha_5 P_t Z_{3t} + \epsilon_1 \tag{5}$$

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[5] See Deodhar and Sheldon (1995) for a discussion of the connection between the market power parameter λ and the concept of conjectural variations.

where Q_t is the quantity of soymeal sold in the export market, P_t is the real soymeal price, Z_{nt} ($n=1,.,3$) are exogenous variables (defined explicitly in Section 4), and ϵ_1 is the error term, where ϵ_1 is $N(\mu,\sigma^2)$. In addition, suppose that the aggregate marginal cost of production takes the following functional form:

(6)
$$MC_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t}$$

Marginal cost is assumed to vary with respect to output Q_t, and W_{nt} ($n=1,.,3$) are proxies for the real input costs of producing soymeal. No constant term is included in the functional form since there will be no variable costs at zero output.

Equation (6) can now be substituted into the profit-maximizing condition (4). Re-arranging terms, the following equation is derived:

(7)
$$P_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t} + \delta \left[\frac{Q_t}{\alpha_1 + \alpha_5 Z_{3t}} \right] + \epsilon_2$$

where the variables are defined as above, and ϵ_2 is $N(\mu,\sigma^2)$. The market power parameter in this equation is nothing but the coefficient δ with a negative sign, i.e., $\lambda = -\delta$.

It should be emphasized here that the market power parameter cannot be estimated if the cross-product variable, $P_t Z_{3t}$, is not specified in the demand function. As described by Bresnahan (1982), since marginal cost data are not readily available, rotation of the demand function around the equilibrium point can trace out the supply relation, which allows calculation of the degree of market power. If no cross-product variable is included in the demand function, the coefficient of Q_t in equation (7) reduces to $(\gamma_1+\delta/\alpha_1)$, and, hence, an identification problem occurs for δ as γ_1 and δ cannot be estimated separately. This problem does not arise if marginal cost is constant with respect to output (see Bresnahan, 1982), however, in this study it is assumed that marginal cost varies with respect to output.

4. Data and Regression Analysis

In order to evaluate the degree of market power, equations (5) and (7) are estimated. In its complete form, (5) is specified as:

$$(5') \qquad Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Z_{1t} + \alpha_3 Z_{2t} + \alpha_4 Z_{3t} + \alpha_5 P_t Z_{3t} + \alpha_6 D1 + \alpha_7 T + \epsilon_1$$

Q_t and P_t are as already defined; Z_{1t} is the real price of a key substitute product, fishmeal. Fishmeal was chosen over other protein meal substitutes due to fishmeal having been the second-largest traded protein meal in the world, and data were available for the time-period of this study. Z_{2t} is the rest of the world (ROW) population that excludes the population of Argentina, Brazil and the U.S. Although the EU-12 has become a major exporter of soymeal, its population is included because there is a certain amount of intra-EU trade in soymeal (Crowder and Davison, 1989). Similarly, Z_{3t} is an index of the gross domestic product of the ROW. T represents a trend variable and D1 is a dummy variable that takes into account the exogenous price increases that occurred in 1973 due to the oil shock. It takes a value of one for 1973 and zero otherwise.

Similarly, equation (7) in its complete form is specified as follows:

$$(7') \qquad P_t = \gamma_1 Q_t + \gamma_2 W_{1t} + \gamma_3 W_{2t} + \delta \left[\frac{Q_t}{\alpha_1 + \alpha_5 Z_{3t}} \right] + \gamma_4 D1 + \gamma_5 T + \epsilon_2$$

The additional variables W_{1t} and W_{2t} are the real soybean price, and the real average ocean freight rate respectively. Until 1974, the world export market for soymeal was dominated by

Brazil, the EU-12, and the U.S. However, since 1975 Argentina has increased its market share which, by 1990, had reached more than 20 percent. In order to see if there is any structural change in the degree of market power after Argentina entered the world export market, the coefficient δ is expressed as a linear function of a structural dummy:

$$\delta = \delta_0 + \delta_1 D2 \tag{8}$$

D2 is the structural dummy which takes a value of zero prior to 1975, and one since 1975, indicating Argentina's entry to the export market. This implies that prior to Argentina's entry into the export market, $\delta=\delta_0$, therefore, the market power parameter $\lambda=-\delta_0$. After Argentina's entry, $\delta=\delta_0+\delta_1$, therefore, $\lambda=-(\delta_0+\delta_1)$.

The variables used in the estimation procedure are summarized and described in Table 1. Annual data on aggregate quantities of world soymeal exports (Q_t) were collected for the period 1966 to 1990 from a USDA staff report (Crowder and Davison). Prices of soymeal (P_t), fishmeal (Z_{1t}) and soybean (W_{1t}) were collected for the same period from various issues of the USDA publications: *Oilseeds and Products*, *World Oilseed Situation and Outlook*, and *Oilseeds: World Markets & Trade*, and from various issues of the FAO publication: *Production Yearbook.* Data on ocean freight rates (W_{2t}) were collected from various issues of the FAO publication: *Trade Yearbook.* Population figures (Z_{2t}) were constructed from a USDA staff report (Urban and Nightingale, 1993). Similarly, indices for gross domestic product were constructed from the UN publication: *Trends in International Distribution of Gross World Product* (1993). The deflator used for deflating the nominal variables was collected from the IMF publication: *International Financial Statistics* (1992, 1994).

Since equations (5´) and (7´) represent a nonlinear simultaneous equations system, they were estimated using a nonlinear three-stage least squares (N3SLS) procedure. All the exogenous variables in the system were used as instruments for the purpose of estimation. The results of estimating these equations are shown in Table 2. In the demand regression, soymeal and fishmeal prices have their expected signs. While the positive coefficient of the variable P_tZ_{3t} dampens the strong negative magnitude of the soymeal price coefficient, it also offsets the negative coefficient of the income variable. Further, the population variable has a statistically insignificant impact on demand. In the first-order condition regression, soymeal exports has a negative coefficient implying that marginal cost is decreasing. The positive coefficients of soybean price, and ocean freight rate are consistent with their expected effect on marginal cost. The relevant coefficients for calculating market power are $\delta_0 = -0.03$ and $\delta_1 = 0.03$. Both the coefficients are statistically different from zero at 10 percent, using a one-tail test, however, they are so close to zero that testing this at any stricter significance level is inconsequential.

The results show that, even before Argentina's entry, the world export market was extremely competitive ($\lambda=0.03$). The effect of Argentina's entry is negligible, but it certainly reinforces the status of this industry as a perfectly competitive one ($\lambda=0$). As noted earlier, the world market for soymeal exports has been virtually dominated by three to four countries, hence, the temptation to argue that the market will be oligopolistic in structure. However, the econometric results run contrary to this circumstantial evidence. Indeed, the nature of competition in this market need not be determined solely by the number of countries participating in the export market.

5. Summary

Recent developments in trade theory are based on the key assumption that international markets are imperfectly competitive. In this context, the aim of this paper has been to evaluate the magnitude of market imperfection in the world market for soymeal exports, an industry where firms based in developed countries are competing with those from developing countries. An earlier study by Yamazaki *et al.* has shown this market to be perfectly competitive, however, their study used a calibration method to measure the degree of competitiveness such that no statistical confidence can be attached to their results. In contrast, the present study has used a structural econometric model originally proposed by Bresnahan (1982) in order to estimate the degree of market power in the soymeal export market. The results presented in this paper show that the world market for soybean exports is perfectly competitive, which does confirm the earlier result of Yamazaki *et al.*. While this single result does not constitute a refutation of the new trade theory, it does underline the importance of careful empirical analysis of market structure and behavior before orthodox trade models are abandoned.

Table 1: Description of Variables*.

Variable	Description
P_t	Real price of soymeal at the port of Rotterdam: $/tonne cif
Q_t	Total world soymeal exports: thousand tonnes/annum
Z_{1t}	Real price of fishmeal at the port of Hamburg: $/tonne fob
Z_{2t}	World population except that of Argentina, Brazil & U.S.
Z_{3t}	Index of world gross domestic product except Argentina, Brazil & U.S.
W_{1t}	Real price of soybean at the port of Rotterdam: $/tonne cif
W_{2t}	Real ocean freight rate, Average of Argentina-Rotterdam and U.S.-Rotterdam rates: $/tonne
D1	Oil shock dummy: 1 for 1973, 0 otherwise.
D2	Dummy for Argentina's entry: 0 until 1974, 1 since 1975.
T	Time Trend
t	1966-1990

* All variables except dummies are expressed in logarithmic form.

Table 2: N3SLS Estimation of the Model.

	Coefficient	t-Ratio
Soymeal Export Demand		
Intercept	59.42*	1.73
Real soymeal price: P_t	-9.92**	-2.21
Real fishmeal price: Z_{1t}	0.40**	2.17
ROW population: Z_{2t}	-0.72	-0.19
ROW income: Z_{3t}	-10.32*	-1.71
Price times income: P_tZ_{3t}	2.21**	2.21
Oil shock dummy: D1	0.29***	1.56
Trend: T	0.23***	1.41
R-square between observed & predicted:	0.98	
Durbin-Watson statistic:	1.83	
First-order condition		
Soymeal exports: Q_t	-0.35*	-2.03
Real soybean price: W_{1t}	1.25**	8.82
Real ocean freight: W_{2t}	0.13	0.86
δ_0	-0.03***	-1.35
δ_1	0.03***	1.39
Oil shock dummy: D1	-0.43*	-1.84
Trend: T	0.44**	2.12
R-square between observed & predicted:	0.62	
Durbin-Watson statistic:	2.48	

** Statistically significant at 0.05 level, 2-tail test
* Statistically significant at 0.05 level, 1-tail test
***Statistically significant at 0.10 level, 1-tail test

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